

MSFC 434

Ares V an Enabling Capability for Future Space Science Missions

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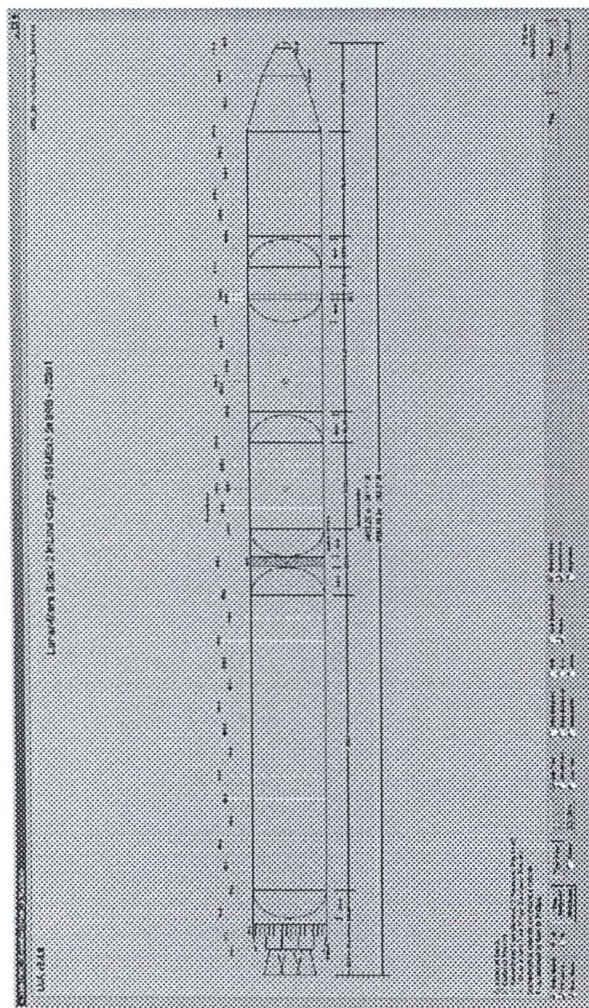
The potential capability offered by an Ares V launch vehicle completely changes the paradigm for future space astrophysics missions. This presentation examines some details of this capability and its impact on potential missions. A specific case study is presented: implementing a 6 to 8 meter class monolithic UV/Visible telescope at an L2 orbit. Additionally discussed is how to extend the mission life of such a telescope to 30 years or longer.



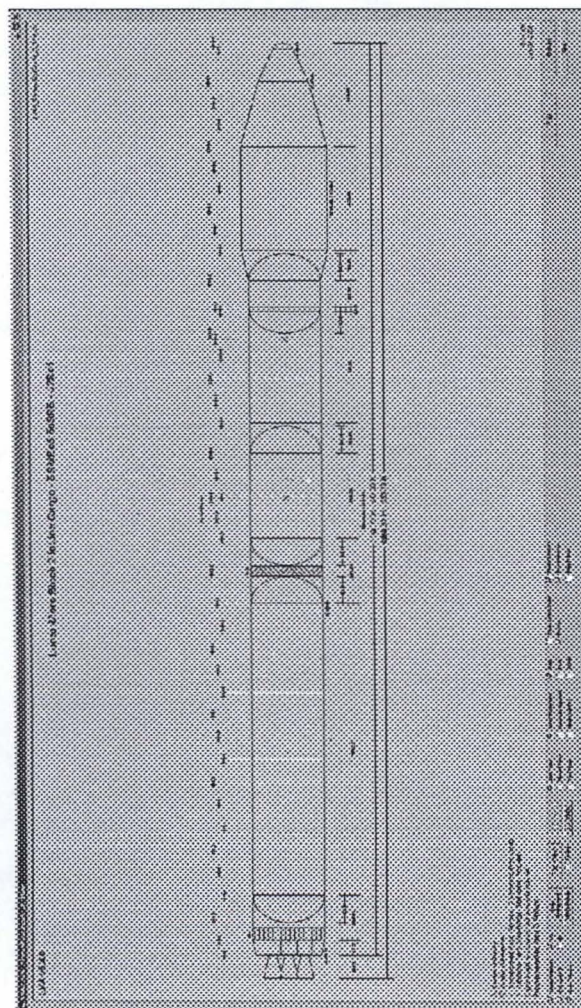
Ares V - Preliminary Shroud Concepts

(from MSFC Ares V Office)

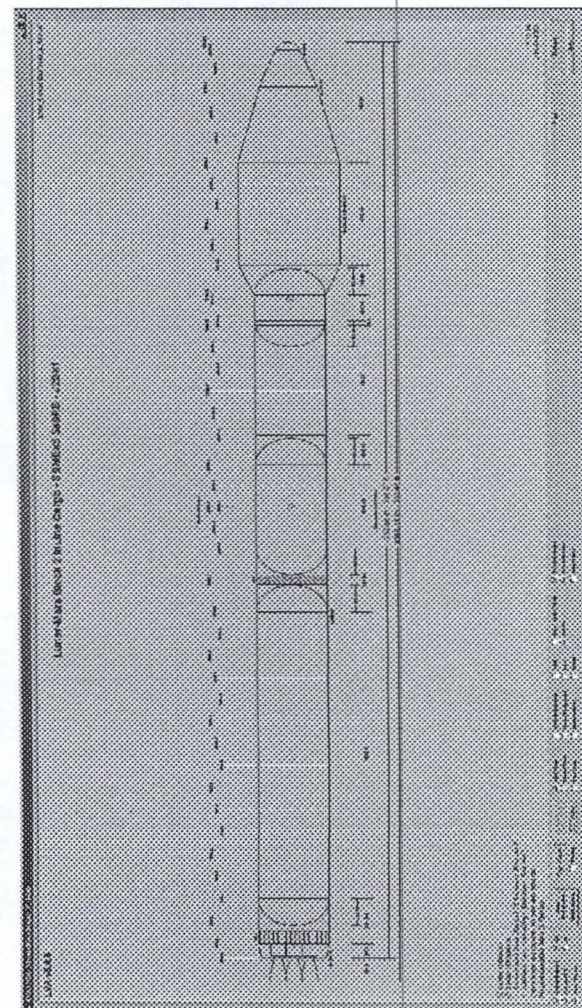
Baseline CaLV 8.4 m Shroud

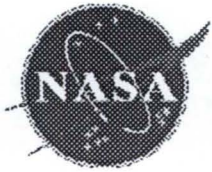


CaLV w/ 10m Shroud



CaLV w/ 12m Shroud

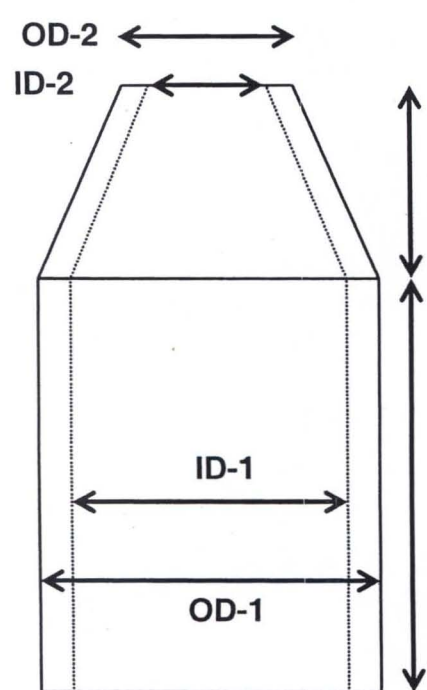




Ares V Preliminary Shroud Dimensions

(from MSFC Ares V Office)

ID is the payload dynamic envelope, not the wall thickness.

		Shroud Outer Diameter		
		8.4-m	10-m	12-m
	Shroud Mass	5.9	8.4	12.5 mT
	OD-1	8.4	10	12 m
	ID-1	7.5	8.77	10.3 m
	H-1	12	12	12 m
	OD-2	4.8	5.75	6.9 m
	ID-2	3.9	4.52	5.2 m
	H-2	6.3	7.5	9 m
Total Height		18.3	19.5	21 m
Payload to SEL2		62	61	60 mT

NOTE: these shroud dimensions are preliminary, are subject to change, and have not been approved by the Ares project office.



Ares V Changes Paradigms

Ares V Mass & Volume enable entirely new Mission Architectures:

- 6 to 8 meter class Monolithic UV/Visible Observatory
- 5 meter cube (130,000 kg) Cosmic Ray Water Calorimeter
- 4 meter class X-Ray Observatory (XMM/Newton or Segmented)
- 15 to 18 meter class Far-IR/Sub-MM Observatory (JWST scale-up)
- 150 meter class Radio/Microwave/Terahertz Antenna
- Constellations of Formation Flying Spacecraft

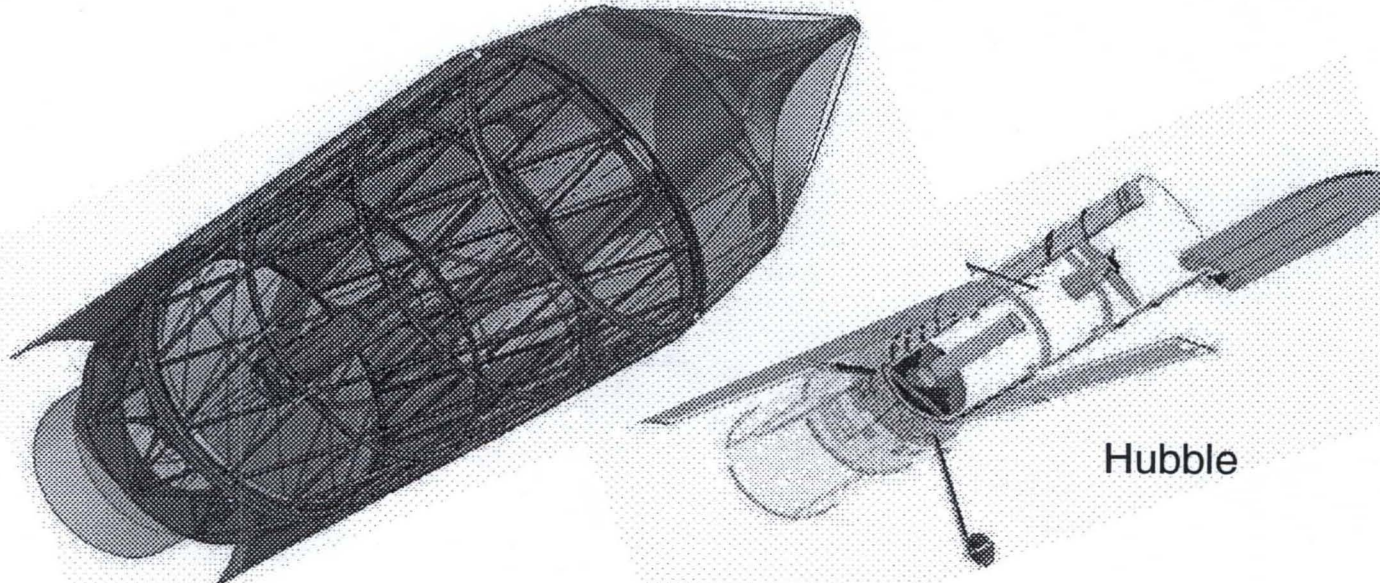
All of these can be built with Existing Technology

Thus allowing NASA to concentrate its Technology Development Investments on Reducing Cost/Risk and Enhancing Science Return

To use a 2018 Launch, should start mission planning now



Case Study: 6 to 8 meter Class Monolithic Space Telescope



Enables Compelling High Priority Science:
UV/Visible Science
Terrestrial Planet Finding Science



Design Concept

6 to 8 meter Monolithic Telescope & tube can fit inside Ares V envelop (8.4 to 12 meter shrouds).

Minimize Cost (& Risk) by using existing ground telescope mirror technology – optics & structure.

8-meter diameter is State of Art

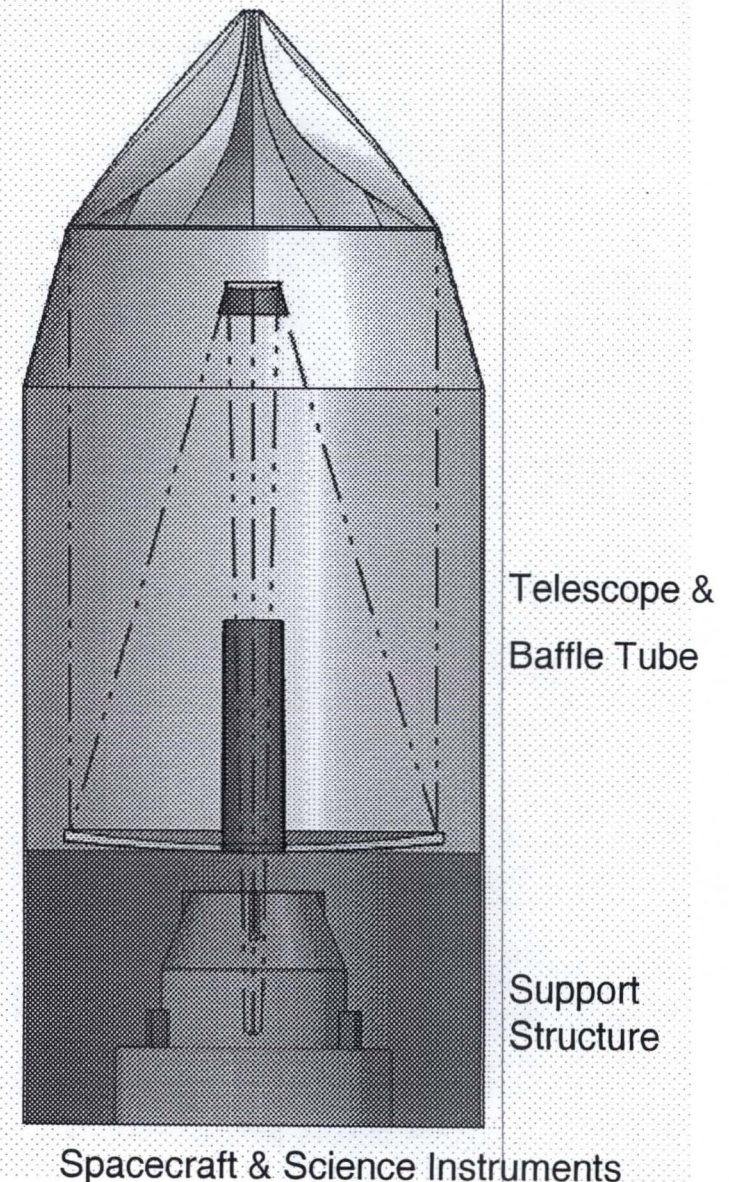
7 existing: VLT, Gemini, Subaru

23,000 kg (6 m would be ~13,000 kg)

~\$20M (JWST PM cost ~\$100M)

7.8 nm rms surface figure (~TPF spec)

Expect similar savings for structure





6 meter Optical Design

Ritchey-Chretien optical configuration

F/15

Diffraction Limited Performance at <500 nm

Diffraction Limited FOV of 1.22 arc minute

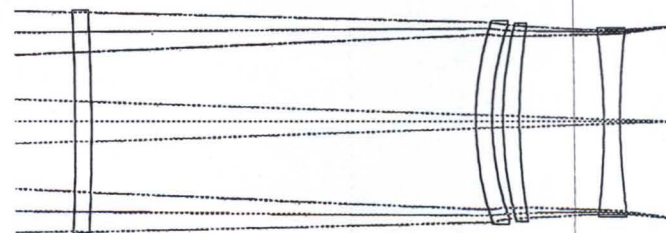
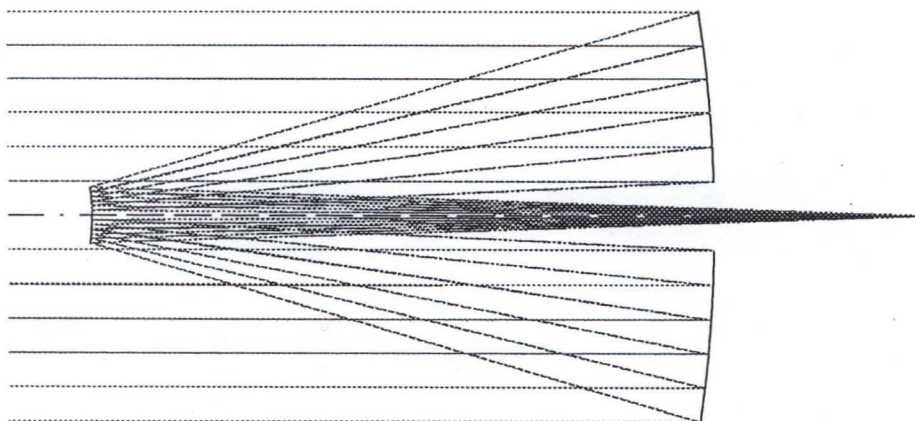
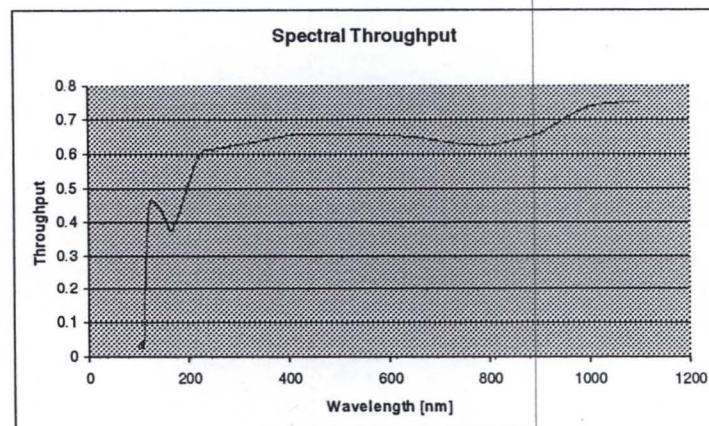
(10 arc minute FOV with Corrector Group)

Coating: Aluminum with Mg F2 overcoat

Average transmission $> 63\%$ for wave lengths of 200 to 1,000 nm

Primary to secondary mirror vertex: 9089.5 mm

Primary mirror vertex to focal plane: 3,000 mm



10 arc min Refractive Corrector Group

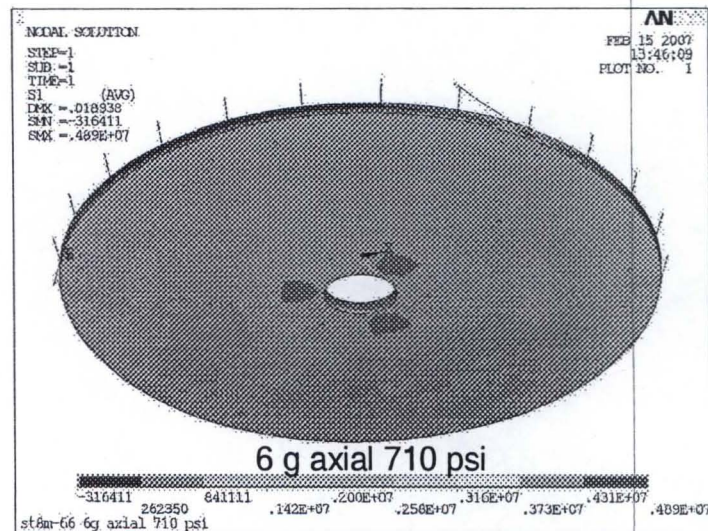
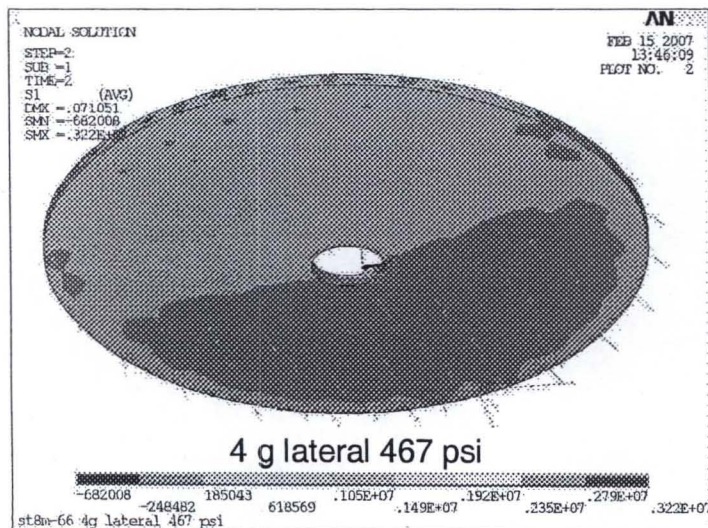
Need to design Reflective Corrector



Structural Analysis

6 to 8 meter class 175 mm thick meniscus primary mirror
can survive launch.

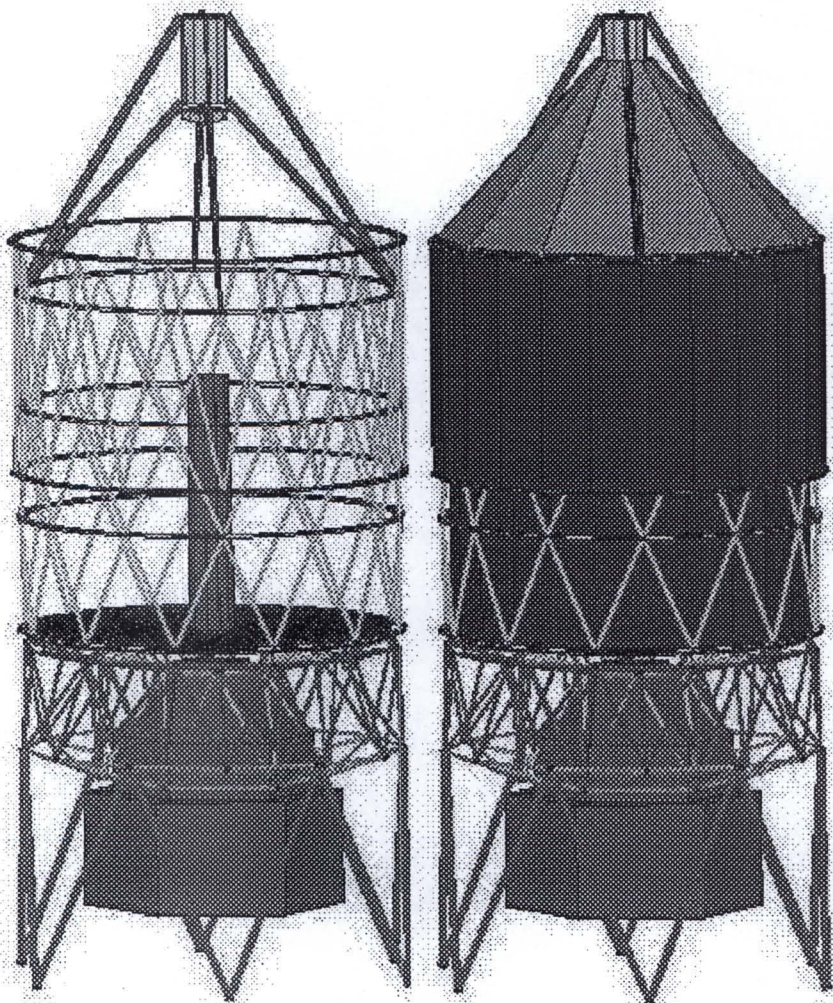
66 axial supports keep stress levels below 1000 psi for 4 g lateral
and 6 g axial equivalent acceleration levels (8.2 m analysis)





Structural Design

Launch Configuration



Tube is split and slides forward on-orbit.

Faster PM or taller shroud may allow for one piece tube.

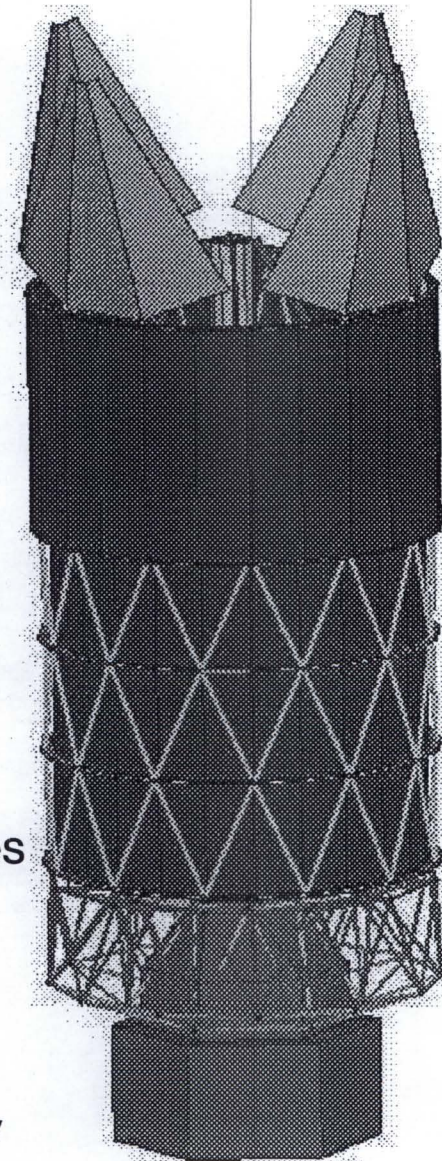
Doors can open/close

Forward Structure is hybrid of Hubble style and four-legged stinger

Truss Structure interfaces with 66 mirror support attachment locations

Launch Structure attaches Truss to Ares V

Operational





6 meter Preliminary Mass Budget

	Mass (Kg)	Heritage	Notes
Primary mirror assembly	20000		
Primary mirror	13,000	calculated	Zerodur 175 mm thk. meniscus
Primary mirror support structure	6,750	estimate	Structural Model
Primary mirror center baffel	250	estimate	Structural Model
Secondary mirror assembly	985		
Secondary mirror	185	calculated	Zerodur 50% light weight
Secondary mirror support & drive	350	estimate	Structural Model
Secondary mirror baffle	50	estimate	Structural Model
Secondary mirror spider	400	estimate	Structural Model
Telescope enclosure	5,600		
Metering structure with internal baffels	4,800	estimate	Marcel Bluth
Rear cover	300	estimate	WAG
Head ring	200	estimate	WAG
Front cover & actuator	300	estimate	WAG
Attitude Determination and Control System	300	JWST	estimate plus JWST scaled
Communications	76	EI63	
Command And Data Handling System	53	JWST	
Power	500	EI63	
Thermal Management System	1060	JWST	400% of JWST
Structures	2,000	estimate	WAG
Guidance and Navigation	50	estimate	50% WAG
Propulsion	250	JWST	
Computer Systems	50	estimate	WAG
Propellant	50	EI63	
Docking station	1,000	estimate	WAG
OTE W / Bus mass	31,974		
Science Instrument	1500	JWST	ISIM, contains Fine Guidance Sensor
Attitude Determination and Control System	300	JWST	estimate plus JWST scaled
Communications	76	EI63	
Command And Data Handling System	53	JWST	
Power	480	EI63	
Thermal Management System	300	EI63	
Structures	2,000	estimate	WAG
Guidance and Navigation	50	estimate	50% WAG
Propulsion	250	EI63	
Computer Systems	50	estimate	WAG
Propellant	1530	EI63	
Docking station	1,000	estimate	WAG

33% Mass Reserve

Science Instrument W / Bus mass 7,589

Total mass = OTE W / Bus + Science Instrument W / Bus =

39,563 kg

8 meter Preliminary Budget is 50,000 kg (16.5% Reserve)



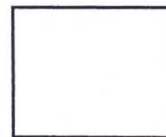
Mission Life

Initial Mission designed for a 5 yr mission life (10 yr goal)
should produce compelling science results well worth the
modest mission cost.

But, there is no reason why the mission should end after 5 or
even 10 years.

Hubble has demonstrated the value of on-orbit servicing

The telescope itself could last 30 or even 50 years.





30 to 50 year Mission Life

Design the observatory to be serviceable

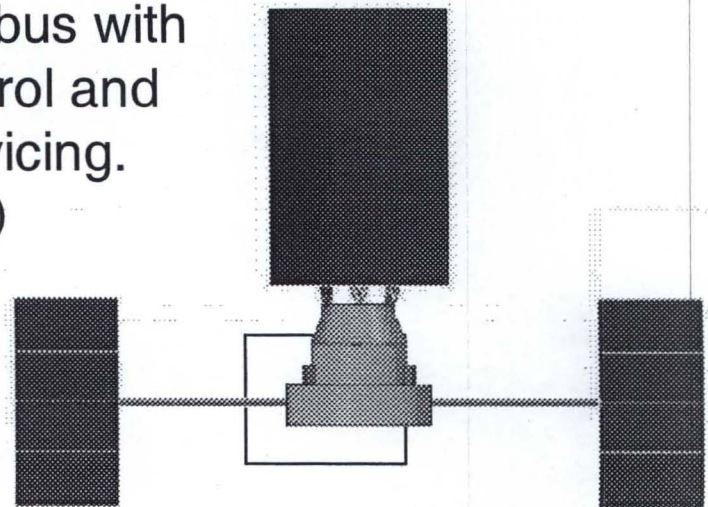
Replace Science Instruments every 3-5 yrs (or even 10 yrs)

Replacement
Spacecraft in ELV

Autonomously Docks to Observatory.
Replaces Science Instruments and
ALL Serviceable Components.



Observatory has split bus with
on-board attitude control and
propulsion during servicing.
(already in mass budget)



Copy Ground Observatory Model – L2 Virtual Mountain



Thermal Analysis

Active Thermal Management via Heat Pipes yields a Primary Mirror with less than 1K Thermal Variation.

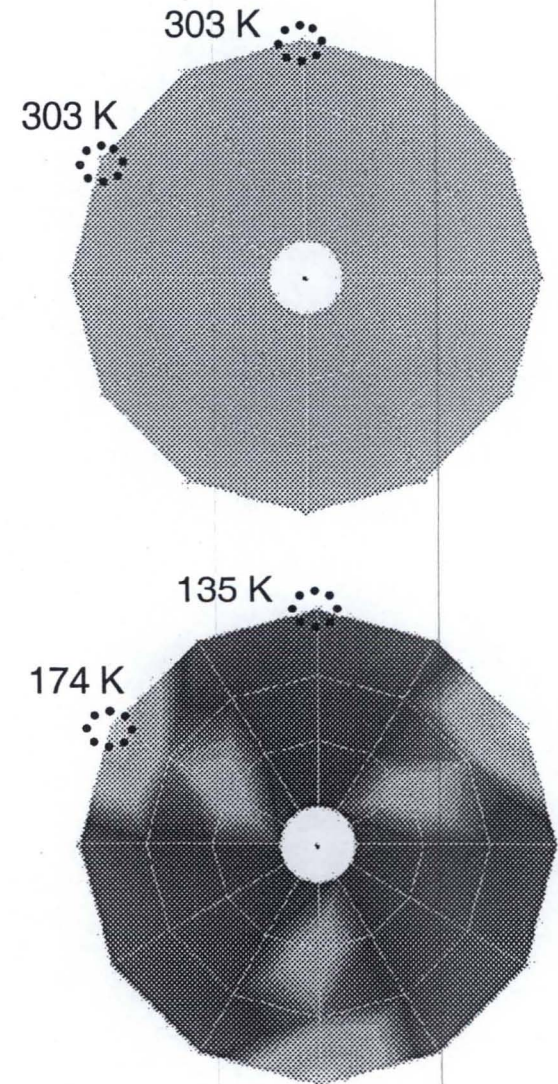
No Thermal Management yields a Cold PM (155K) with a 39K Thermal Variation.

Thus, possible End of Life use as a NIR/Mid-IR Observatory.

Figure Change will be driven by CTE Change from 300K to 150K

Zerodur CTE is approximately 0.2 ppm.

ULE or SiO₂ CTE is approx 0.6 ppm.





Conclusion

Ares V Mass & Volume capabilities enable entirely new Mission Architectures:

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- Constellations of Formation Flying Spacecraft

Conceptual Design Study indicates that a 6 meter class monolithic UV/Visible Observatory is achievable, compelling and could be ready for an early Ares V launch before 2018.

Primary technical challenge is autonomous rendezvous & docking for servicing

Request support for Decadal Consideration and Concept Development